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# Nested Grid Modeling Approach for Assessing Urban Ozone Air Quality

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16. ABSTRACT

This paper describes an effort to interface the modeled concentrations and other outputs of the Regional Oxidant Model (ROM) as an alternative set of input files to apply in Urban Airshed Model (UAM) simulations. Five different days exhibiting high ozone concentrations during the 1980 ozone season were simulated by the UAM for the New York metropolitan area for a base scenario and for different sets of initial and boundary conditions and winds from the ROM. The methodology of integrating the ROM results into the UAM processor system is discussed. The modeled UAM ozone concentrations are compared with measured values for the various model input data scenarios in assessing the performance of the nested grid modeling approach. The results indicate relatively good agreement over the New Jersey/New York portion of the UAM domain, and an underprediction of ozone levels over Connecticut.

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# NESTED GRID MODELING APPROACH FOR ASSESSING URBAN OZONE AIR QUALITY

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## 1. INTRODUCTION

Previous studies[1] on the application of the Urban Airshed Model (UAM) to the New York metropolitan area indicate that although the predicted peak ozone concentrations over Connecticut were in reasonable agreement with the measured concentrations, the model overpredicted the ozone levels over New Jersey and New York portions of the modeling domain. Sensitivity analysis of UAM[2,3] indicated that the initial and boundary concentration fields influence significantly the concentrations predicted in the interior of the modeling domain during a single day simulation. In these earlier applications of the model, the initial and boundary conditions were estimated from sparse air quality monitoring data within and outside the modeling domain. Specific knowledge and quantification of the limitations associated with the initial and boundary conditions in the UAM simulations are essential for interpreting the modeling results properly. Although the impact of initial conditions can be minimized through a multi-day simulation, the uncertainty associated with the boundary conditions can be minimized only through a dense network of monitoring stations outside the modeling domain. Even if such dense networks were available, it is not possible to define the initial and boundary concentrations resulting from the imposition of specific control strategies proposed for future years on the emission sources within and outside the modeling region. Further, it has been demonstrated that the predicted ozone levels are very sensitive to the wind field employed in the simulation[4]. The uncertainty in the wind field stems, in general, from the lack of dense meteorological observations to construct the field. Thus, it is of utmost importance to evaluate the representativeness of the model inputs prior to making any recommendations regarding the relative merit of the various emission control measures in reducing the ambient ozone concentrations.

One of the objectives of the Regional Ozone Modeling for Northeast Transport (ROMNET) project[5] is to provide initial and boundary concentrations for urban-scale modeling based on the EPA's Regional Oxidant Model (ROM) simulations. In the present study, we examine the feasibility and use of ROM predictions to provide an alternate set of initial and boundary concentrations for the New York metropolitan area and develop a methodology to interface ROM and UAM. Five days with high ozone concentrations during the 1980 ozone season were simulated with UAM for the New York metropolitan area using a series of wind fields with initial and boundary conditions adopted from ROM. The modeled ozone concentrations are compared with measured values to assess the performance of this nested grid modeling approach in simulating the observed ozone air quality over the New York metropolitan area. The results indicate that there is a good agreement between the predicted and measured ozone concentrations over the New Jersey/New York portion of the domain, and an underprediction of the ozone levels over Connecticut. The methodologies used to integrate the ROM output to drive the UAM, and the results from this approach are discussed in this paper.

## 2. DESCRIPTION OF THE REGIONAL AND URBAN-SCALE MODELS

The salient features of the Regional Oxidant Model (ROM) and the Urban Airshed Model (UAM) are described briefly in this section. Detailed descriptions of the models are available elsewhere.[6,7,8,9,10]

### 2.1 ROM

The EPA's Regional Oxidant Model (Version 2.0) is designed to simulate the various physical and chemical mechanisms and processes affecting photochemical pollutant concentrations over spatial scales of 1000 km and covering multi-day scenarios. The model utilizes the Carbon Bond IV chemical kinetic mechanism[11] which consists of 70 reactions with 28 chemical species. The mechanism also considers the reactivity associated with biogenic VOC emissions through isoprene. The model includes a diagnostic shallow layer and 3 prognostic layers above it constituting a total of 3 1/2 vertical layers. The shallow layer is adjacent to the ground to simulate dry deposition processes and sub-grid scale chemistry while the nighttime vertical wind shear, stability stratification, cumulus cloud effects are treated in the three layers above the surface layer.[8] Anthropogenic emissions are taken from the 1980 NAPAP 5.3 inventory and gridded into the ROM domain with a grid spacing of about 18.5 km. The ROM domain extends approximately from north of Richmond, VA, to the Canadian border, and from east of Dayton, OH, to the New England coast.

### 2.2 UAM

The Urban Airshed Model, developed by Systems Application, Inc., (SAI), is a 3-dimensional grid model designed to simulate ozone concentrations over urban areas. The areal extent to which the model has been applied ranges up to 250 km x 250 km with a grid size of 2 to 10 km. In this application, the extent of the domain is 248 km E-W and 200 km N-S, with the southwest corner set at approximately Trenton, NJ. The number of levels in the vertical is user-specified and ranged from 2 to as high as 5 from the surface up to the base of the elevated stable layer or the top of the mixed layer which is considered as the top of the modeling region. In this study, the layer between the surface and the elevated stable layer was divided into 4 layers with varying thickness as the mixed layer grows during the day. The time periods of simulation are on the order of 0.5 to 3 days; in this exercise, the simulations were performed from 0400 to 2000 Hrs. The model utilizes the Carbon Bond II chemical kinetics mechanism[12] consisting of a 69 reaction mechanism and the SHASTA integration scheme to solve the advection terms in the conservation of mass equations. The 1980 gridded emissions inventory generated for the Oxidant Modeling for the New York Metropolitan Area Project (OMNYMAP)[1] on a 8 km by 8 km grid was used as the emissions data base in this application. Some of the salient features of ROM and UAM are presented in Table I.

## 3. METHODOLOGY FOR INTERFACING ROM AND UAM

The variables which need to be derived from the coarse ROM grid in order to define inputs for the fine UAM grid are the pollutant concentration fields, layer heights, and wind fields. It is necessary to match the ROM layer heights appropriately with the UAM levels so that the pollutant concentrations can be apportioned into the corresponding layers. In a similar manner, the wind field from ROM needs to be incorporated into the UAM. A brief description of the methodology by which the transfer of pertinent variables is accomplished is given below.

### 3.1 Chemistry

Whereas the ROM utilizes the new CB-IV chemical mechanism to simulate the smog chemistry, the UAM applied in this study uses the CB-II chemical mechanism. Appropriate transformations were applied to the ROM CB-IV concentrations to determine the UAM CB-II species taking into consideration the differences in condensing mechanisms that exists between the two schemes.

### 3.2 Modeling Domain

The areal extent covered by ROM simulations is from 38·N to 45·N in the north-south and from 69·W to 84·W in the east-west directions. The UAM simulations for the New York metropolitan area covered approximately the region of 40·N to 42·N and from 71.5·W to 75·W. In this paper, this UAM domain is referred to as the OMNYMAP region. Since the grid size adopted for the OMNYMAP region is smaller than that of the ROM, the OMNYMAP region needs to be coupled with the corresponding ROM portion of the domain. It is also generally advantageous to place the lateral boundaries of the limited area domain far from the region of interest so that any incompatibilities between the specified boundary conditions and the internally generated model solutions do not contaminate the central region of interest. The ROM and OMNYMAP grid locations are presented in Figure 1. It should be noted that the ROM grids extend two cells beyond the OMNYMAP domain. This was specifically chosen to better define the influx of pollutants into the urban-scale modeling domain from the south and west directions. Further, since the ROM simulations lack the spatial detail needed for the urban-scale simulations, concentrations averaged over certain time and space scales were considered to be more appropriate in this transfer process rather than a direct hour-to-hour and grid-to-grid transfer approach.

### 3.3 Spatial and Temporal Averaging for the Concentrations

The methodology applied to obtain temporal averages of the concentrations was a simple 3-hr running-average scheme, and this time-averaged concentration was assigned to the central hour. In other words, concentrations at each grid cell for hour 1, 2 and 3 were averaged and assigned to the hour 2 for that cell at each of the ROM layers. This data base was generated after the concentrations for the OMNYMAP region were transformed from the CB-IV to the CB-II configuration. To assess the magnitude of

concentrations predicted by ROM, spatial averages within ROM layer 2 and layer 3 for the OMNYMAP domain were computed for each of the species for each hour. Focusing attention on the average ozone concentrations for the 5 days of interest, the ROM layer 3 data were found to be in the range of 45 to 70 ppb while the layer 2 concentrations ranged from 70 to 92 ppb. The aircraft spiral data, obtained under the 1980 NECRMP study,[13] indicate that the ozone concentrations at the top of the mixed layer for the five days were generally on the order of 60 to 85 ppb (see Table II). Hence, it was decided to adopt the ROM layer 2 average concentrations as the concentration for the top of the modeling region or TOPCON value in the UAM simulations. The average layer heights from ROM simulations and the mixing heights and region top levels from the UAM simulations of the OMNYMAP domain are given in Table III. The ROM layer 2 heights are more consistent with the mixing heights and region top values estimated in the OMNYMAP analysis than the ROM layer 3 heights. The OMNYMAP data were based upon available upper air temperature soundings and pollutant data.[13]

### 3.4 Initial Conditions

Data sets, consisting of the hourly average concentrations corresponding to 0400 Hrs for the ROM layer 1 and the corresponding layer 2 average values, were utilized to define the initial concentration field for each of the UAM simulations. The ROM layer 1 values were interpolated using an inverse distance squared weighting scheme to the OMNYMAP domain grid points and were assigned to the UAM level 1. The average concentrations derived from ROM layer 2 were assigned to the UAM's layer 4 and TOPCON level. For the intermediate levels of the UAM, concentrations were obtained by linear interpolation for each of the grid cells. This method is shown schematically in Figure 2.

### 3.5 Boundary Conditions

The procedure adopted for prescribing the south and west side boundaries was as follows: The ROM layer 1 concentrations corresponding to the three cells at the south and west boundaries were averaged and linearly interpolated to the OMNYMAP-grid cells for each hour. Similarly for the north and east side boundaries, the ROM layer 1 values corresponding to the two cells (see Figure 1 for the domain) were averaged and interpolated to the OMNYMAP grid for each hour. The concentrations at the top of the modeling domain and for cell 4 were specified from ROM layer 2, and the intermediate levels were obtained by linear interpolation. This procedure was followed from 0400 to 1000 hours, same as the methodology applied in the previous UAM application to the OMNYMAP domain.[1] For the remaining hours of simulation the boundary cell concentrations were assumed to be invariant with height on the assumption that the layers will be well mixed as the internal boundary layer grows rapidly. In other words, the interpolated ROM layer 1 values were assigned to all the 4 levels of UAM and the hourly averaged ROM layer 2 concentrations were assigned to the TOPCON value.

### 3.6 Wind Field

The wind field is an important variable which determines the transport of pollutants within the modeling domain. In this study, the focus was not only on the assignment and transfer of pollutant concentration fields from ROM to UAM for the OMNYMAP domain but also on the assessment of the choices for the wind field in simulating the ozone air quality over the New York metropolitan area. Under OMNYMAP study, a diurnally varying but spatially invariant wind was utilized. It should be noted that the ROM-generated wind field was based upon a combination of interpolation and solution to the shallow water equations under low-level inversion condition for the layer 1.[6,8] In this study, we utilized the ROM layer 1 east-west and north-south components (U and V) which were interpolated to the OMNYMAP grid locations using the inverse distance squared weighting scheme. The winds were assumed to be invariant with height. The rationale for such a procedure was that the pollutant concentrations were basically extracted from layer 1 of ROM for the UAM simulation of the OMNYMAP domain. Currently, these wind algorithms of ROM are being reviewed and modified to alleviate some of the uncertainties in defining the mean flow for the regional-scale simulations. For comparison purposes, another data base was assembled consisting of the meteorological data from the National Weather Service (NWS) surface stations and those available from State agencies (see Figure 3). This data base was interpolated to the OMNYMAP grid locations employing a non-divergent wind field processing algorithm[14] for specifying a spatially (horizontally) and temporally varying wind field for the level 1. Again, the winds were assumed to be invariant with height in this analysis.

## 4. MODELING DESIGN

The study design consisted of developing six scenarios (including a base case) of UAM inputs for different combinations of wind fields, initial conditions, and boundary conditions. The BASE RUN represents the set of inputs used in the OMNYMAP study (i.e., without ROM interfacing). The scenarios were based on three sets of wind fields: 1) OMNYMAP wind field, 2) ROM-generated wind field, and 3) a local wind field generated by interpolating available surface data from the NWS and local State agencies; and three sets of initial and boundary conditions: 1) OMNYMAP initial and boundary conditions, 2) ROM-generated initial and boundary conditions as discussed above, and 3) ROM-generated boundary conditions and OMNYMAP initial conditions. These scenarios are referred to as "RUN 1-5" and "BASE" throughout this text and are listed in Table IV. UAM simulations were performed for each of five days for the six scenarios, and evaluated against measured ozone data to assess the effectiveness of the interfacing methodology in reproducing the observed ozone air quality over the New York Metropolitan area.

In general, the UAM input files were identical to those employed in the OMNYMAP study with exceptions to those files providing initial and boundary conditions, and wind fields (note, in all

scenarios the OMNYMAP mixing heights were used). Brief discussions of the relevant files which reflect changes due to the modeling design (described above) are given below.

4.1 Initial Concentrations (IC)

The model input consists of pollutant concentrations at the beginning of the simulation at each grid for each level. As described previously, the ROM concentrations for 0400 Hrs from layer 1 and average concentrations from layer 2 are used to generate each data set. Examination of the concentrations predicted by the ROM and observed air quality data indicates that there are differences between the two sets of data. In general, the Reactive Organic Gas (ROG) concentrations from ROM are lower than those based on OMNYMAP data while in the case of $NO_x$ it is vice versa. For ozone, the ROM peak concentrations were predicted over the Atlantic Ocean in the southeast sector similar to that of OMNYMAP but the levels are higher than those of OMNYMAP. Perhaps, these differences can be attributed to the wind field, emissions mix and speciation characteristics employed in the modeling scenario. Also, it should be noted that the OMNYMAP initial concentration data for some of the pollutants were based upon sparse observations and accounted for the population distribution while the ROM predictions are based upon the physical and chemical mechanisms involving the emissions in the region.

4.2 Boundary Concentrations (BC)

The concentrations for the UAM boundaries from the ROM data base were generated following the procedures previously outlined. In general, at the southwest corner cell, the concentration levels of ROM are much lower than those of OMNYMAP for CO, $NO_x$ and ROG. The OMNYMAP data, which were based upon a sparse set of measurements, are often a factor of 2 to 5 higher than the corresponding ROM predicted concentrations for CO, $NO_x$ and ROG. However, in the case of ozone, the differences are much smaller with the exception of two days (16 and 21 of July 1980) which show a more pronounced diurnal peak in the OMNYMAP data base. The reactivity of the precursor pollutants as characterized by the ROG/$NO_x$ ratio for the southwest corner cell is shown in Figure 4. It is interesting to note that the ROM-based data are typically lower than the OMNYMAP data in terms of the reactivity, especially during the afternoon hours for 22 July 1980.

4.3 Top Concentrations (TC)

The concentrations at the top of the modeling region either were from ROM layer 2 averages or were from the OMNYMAP study. The ROG concentrations based on ROM are higher than OMNYMAP while the $NO_x$ levels are vice versa. A comparison of the reactivity of the precursor pollutants (ROG/$NO_x$), shown in Figure 5, indicates that ROM data are about a factor of 2 to 4 times higher than that of OMNYMAP data. In the case of ozone, with the exception of 22 July 1980, the ROM data average approximately to the same level as that of OMNYMAP.

### 4.4 Winds

As discussed previously, the ROM wind fields of layer 1 were interpolated to the OMNYMAP grid locations and were assumed to be invariant with height. Also, a second wind field comprised of measurements from local State agencies and NWS data were utilized to provide a non-divergent and vertically invariant wind field called LOCAL. The ROM winds were generally found to have a more westerly bias when compared with the LOCAL winds which exhibit a pronounced southwesterly component, similar to the vector-averaged wind methodology used in the OMNYMAP study.

## 5. RESULTS AND DISCUSSION

The UAM simulations were performed for each of the five days with a combination of initial and boundary conditions generated from ROM and OMNYMAP, and with three sets of wind field derived from ROM and the local surface network. The analysis focuses on assessing the capability of the various combinations of initial and boundary concentrations and the wind fields in reproducing the observed ozone concentration field over the New York metropolitan area.

### 5.1 Comparison of Measured and Predicted Concentrations

#### 5.1.1 Domain Maxima

The measured and predicted maxima over the modeling domain for each of the UAM simulations (see Table IV) for the five days are given in Table V. It should be noted that the peak ozone concentrations were measured over Connecticut on all the five days. A cursory examination of the maxima suggests that RUNs 1, 2, and 3 did not predict the peak ozone as well as the BASE, RUNs 4 and 5. To examine the spatial behavior of the predictions, the measured and predicted maxima over the New Jersey, New York and Connecticut portions of the domain are presented in Table VI. RUNS 1, 2, and 3 show relatively good performance over the BASE case for the New York and New Jersey portions of the domain but these simulations underestimate the peak ozone levels over Connecticut. The degree of underprediction over Connecticut in the case of RUNs 1, 2 and 3 which utilize Boundary/Initial Concentrations (BC/IC) specified from ROM could, in part, be related to an acknowledged westerly bias in the ROM wind field resulting in the displacement of the regional plume from Connecticut towards the Atlantic Ocean. Whereas the BASE and RUN 4 predict ozone concentrations reasonably well over Connecticut, these simulations exhibit considerable overprediction over the New Jersey and New York portions of the domain. The overprediction over New Jersey and New York regions for the BASE and RUN 4 may be attributed to the uncertainties in the prescribed pollutant levels at the boundaries. In contrast, RUN 5 which incorporates ROM outputs for specifying the lateral and top boundary conditions and the IC from the measured data (same as the BASE run) predicts the peak ozone levels reasonably well over each of the three geo-political regions. Thus, these results clearly demonstrate the influence of the IC levels on the

predicted ozone peak levels in the case of a single day simulation. The influence of IC over the modeling domain could be minimized by performing multi-day simulations.

### 5.1.2 Cumulative Frequency Plots

Figure 6 shows the cumulative frequency distributions of maximum hourly ozone concentrations measured over the monitoring network and those predicted over the modeling domain for all the five days for each of the three geo-political regions for the BASE, RUNs 1, 3 and 5. Each of the points plotted here represents a percentile value (unpaired in space) at 5% intervals ranging from 5 to 100%. A one-to-one line reflecting perfect agreement together with the ±10% bounds around the perfect prediction are also shown in Figure 6. Examination of these percentile plots show that BASE and RUN 5 simulations tend to overpredict over the New Jersey portion of the domain, and predictions from RUNs 1 and 3 provide a closer agreement with the observations. Over the New York region, the BASE and RUN 5 overpredict but RUNs 1 and 3 appear to perform well. In the case of Connecticut, RUNs 1 and 3 show underprediction while the predictions from BASE and RUN 5 are confined to the ±10% bounds. These results complement the earlier discussion on the domain maxima.

### 5.1.3 Scatter Plots

Figures 7 and 8 show, as an example, the scatter plots of observed versus predicted concentrations (paired in time and space) for two of the five days, namely, 16 and 22 July, 1980. Also shown in the plots are the one-to-one line and the ±30% envelope around the perfect prediction. In the case of 16 July, the BASE and RUN 4 show considerable overprediction for the measured levels at the low end, while RUNs 1 and 3 show significant underprediction at the high end of the measured concentrations. Note, RUN 5 appears to perform better for this day when emphasis is placed on high values. For 22 July, all the simulations are quite reasonable with much less scatter about the perfect prediction line. These results of the paired comparison are also consistent with the earlier discussion.

## 5.2 Ozone Concentration Fields

Figures 9 and 10 show the distribution of the maximum predicted ozone concentrations over the modeling region for two of the five days (included here as an example) for the BASE, RUN 1 and 3 simulations with the UAM and output from ROM. Since each of these distributions is a composite consisting of the maximum predicted concentration at each grid cell over the simulation period, an examination of the isopleths should provide information on the shape and direction of the ozone plume in the region. A subset of the simulations is presented here to demonstrate the role of the wind field on the predicted concentrations; note that the BASE run uses a vector-averaged spatially invariant but temporally varying wind field based on NWS data, while RUN 1 is

based on wind field interpolated from the ROM output, and RUN 3 utilizes a non-divergent, interpolated wind field generated from NWS and other local stations.

The BASE run with winds for both days from south to southwest has peak ozone concentrations aligned along the urban corridor of New York City and Connecticut, while ROM exhibits a peak over the Long Island Sound for one of the days (16 July) and over Connecticut for the second day (22 July). As noted before, for both days ozone maxima exceeding 200 ppb were measured over Connecticut. RUN 1 and RUN 3 simulations, which differ only in the wind fields, show a difference of 56 ppb in the peak predicted concentrations over Connecticut (153 ppb vs 209 ppb) for the 16 July case, and a difference of only 12 ppb (152 ppb vs 164 ppb) for the 22 July case. The orientation of the concentration isopleths in the case of 16 July is east-west in RUN 1 while for RUN 3, the concentration is southwest-northeast. On the other hand, for 22 July both runs exhibit a southwest-northeast orientation of the ozone plume. Thus, these simulations demonstrate the influence of the wind fields on the predicted ozone concentration distribution over the urban area.

## 6. SUMMARY

In this study, a nested grid modeling system was developed and applied to predict the ozone levels over an urban area. The ROM data base was suitably modified to match the inputs needed for the UAM's application to the New York metropolitan area. A number of simulations were performed consisting of various combinations of IC, BC and wind fields for five high ozone days of 1980. The results of this nested grid modeling system suggest that development of initial and boundary conditions and wind fields must be considered carefully in order to minimize errors in the predicted peak ozone concentrations over the modeling domain. Results using ROM-based boundary conditions showed enhanced agreement with observed ozone concentrations over the New Jersey and New York portions of the modeling domain relative to UAM boundary conditions developed from a limited number of upwind monitors.

Currently, we are utilizing an updated version of the UAM which includes (a) CB-IV chemical kinetics that is compatible with ROM, and (b) an improved numerical scheme for advection in order to perform multi-day simulations of ozone air quality over the New York metropolitan area.

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Table I

Model Characteristics

| Features | ROM | UAM |
|---|---|---|
| Spatial Scales | 1000 km | 50-250 km |
| Temporal Scales | 3-30 Days | 0.5 - 2 Days |
| Function | Long Range Pollutant Transport and Multi-Day Effects Pollutant Levels | Interurban and Urban-Scale Variability in |
| Physical and Chemical Processes | Horizontal & Vertical Transport & Diffusion Carbon Bond IV-28 species Dry Deposition Cloud Effects Terrain Effects | Horizontal & Vertical Transport & Diffusion Carbon Bond II-11 species Dry Deposition Terrain Effects* |
| Emissions | Anthropogenic and Temperature Adjusted Biogenics | Anthropogenic |
| Model Structure | | |
| Vertical Resolution | 3 1/2 Layers | 2 - 5 Layers |
| Horizontal Resolution | 18.5 km | 2 km to 10 km |
| Temporal Resolution | 1 Hour | 1 Hour |

*Not included in the current UAM applications.

Table II

Ozone Concentration (ppb) at the Top of the OMNYMAP Modeling Region And the Range of Average Ozone Concentrations from ROM

| | | ROM | |
|---|---|---|---|
| Day | OMNYMAP* Data | Layer 2 Range | Layer 3 Range |
| 071680 | 85 | 72-91 | 46-63 |
| 072180 | 74 | 66-97 | 47-71 |
| 072280 | 60 | 77-93 | 54-72 |
| 080680 | 65 | 70-84 | 49-62 |
| 080880 | 70 | 60-79 | 46-66 |

*Based upon aircraft spiral data (NECRMP, 1982).

Table III

Range of ROM Layer Heights (M) Above Ground and Range of Mixing Heights and Top of the Modeling Region

| | ROM* | | OMNYMAP** | |
|---|---|---|---|---|
| Day | Layer 2 Range | Layer 3 Range | Mixing Height Range | Top of the Modeling Region Range |
| 071680 | 1393-1619 | 1583-3668 | 450-1460 | 1000-1460 |
| 072180 | 1594-1787 | 1816-4595 | 285-1895 | 1000-1895 |
| 072280 | 1336-1710 | 1490-3850 | 315-1625 | 1000-1625 |
| 080680 | 1022-1352 | 1384-3802 | 120-1145 | 1000-1240 |
| 080880 | 1609-1847 | 1509-4139 | 345-1400 | 1000-1400 |

*Average ** From UAM Simulations of OMNYMAP (Rao, 1987)

Table IV

Matrix of Simulations Performed For Each of the 5 Days

| RUN | Initial/Boundary Concentrations | Winds |
|---|---|---|
| BASE | OMNYMAP | OMNYMAP[1] |
| RUN 1 | ROM | ROM |
| RUN 2 | ROM | OMNYMAP[1] |
| RUN 3 | ROM | LOCAL |
| RUN 4 | OMNYMAP | LOCAL |
| RUN 5 | OMNYMAP[2], ROM[3] | LOCAL |

[1]Spatially invariant but diurnally varying
[2]Initial conditions from OMNYMAP
[3]Boundary conditions and TOPCON are from ROM

Table V

Location* and Hour of Occurrence for the Predicted and Measured Maximum Ozone Concentration (ppb).

| Day | Parameter | Base | RUN 1 | RUN 2 | RUN 3 | RUN 4 | RUN 5 | Measured |
|---|---|---|---|---|---|---|---|---|
| 071680 | CONC | 269 | 153 | 189 | 209 | 266 | 224 | 291 |
| | LOC | 12E,9N | 17E,17N | 24E,19N | 15E,16N | 14E,9N | 17E,15N | 20E,19N New Haven |
| | HR | 17 | 17 | 17 | 17 | 18 | 17 | 14 |
| 072180 | CONC | 202 | 161 | 167 | 182 | 257 | 259 | 303 |
| | LOC | 18E,14N | 10E,2N | 20E,18N | 8E,4W | 13E,10N | 13E,9N | 18E,13N Stratford |
| | HR | 14 | 17 | 16 | 16 | 13 | 13 | 15 |
| 072280 | CONC | 181 | 152 | 163 | 167 | 223 | 229 | 227 |
| | LOC | 18E,19N | 20E,19N | 17E,18N | 13E,15N | 16E,13N | 10E,12N | 20E,19N New Haven |
| | HR | 15 | 16 | 16 | 16 | 15 | 15 | 14 |
| 080880 | CONC | 267 | 172 | 178 | 193 | 250 | 243 | 249 |
| | LOC | 13E,10N | 17E,12N | 18E,15N | 13E,15N | 12E,11N | 12E,12N | 18E,13N Stratford |
| | HR | 16 | 16 | 17 | 18 | 16 | 15 | 13 |
| 808080 | CONC | 266 | 153 | 171 | 205 | 304 | 260 | 246 |
| | LOC | 12E,9N | 16E,2N | 24E,18N | 17E,14N | 17E,13N | 17E,13N | 18E,13N Stratford |
| | HR | 17 | 16 | 17 | 17 | 17 | 17 | 13 |

*Measured from SW corner of the domain.

Table VI

Maximum Observed Over the Network and Maximum Predicted Concentration (ppb) Over the Domain for Geo-Political Regions Included in the Modeling Domain

DOMAIN MAXIMA - NJ

| RUN | 0716 | | 0721 | | 0722 | | 0806 | | 0808 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | OBS | PRED | OBS | PRED | OBS | PRED | OBS | PRED | OBS | PRED |
| BASE | 127 | 217 | 145 | 180 | 97 | 137 | 97 | 203 | 121 | 231 |
| RUN 1 | 127 | 120 | 145 | 155 | 97 | 116 | 97 | 106 | 121 | 112 |
| RUN 2 | 127 | 117 | 145 | 156 | 97 | 119 | 97 | 127 | 121 | 118 |
| RUN 3 | 127 | 138 | 145 | 182 | 97 | 137 | 97 | 147 | 121 | 119 |
| RUN 4 | 127 | 230 | 145 | 222 | 97 | 157 | 97 | 194 | 121 | 210 |
| RUN 5 | 127 | 138 | 145 | 216 | 97 | 166 | 97 | 192 | 121 | 179 |

DOMAIN MAXIMA - NY

| RUN | 0716 | | 0721 | | 0722 | | 0806 | | 0808 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | OBS | PRED | OBS | PRED | OBS | PRED | OBS | PRED | OBS | PRED |
| BASE | 152 | 269 | 240 | 199 | 158 | 164 | 171 | 267 | 155 | 266 |
| RUN 1 | 152 | 144 | 240 | 138 | 158 | 135 | 171 | 154 | 155 | 134 |
| RUN 2 | 152 | 141 | 240 | 143 | 158 | 147 | 171 | 155 | 155 | 134 |
| RUN 3 | 152 | 188 | 240 | 178 | 158 | 167 | 171 | 193 | 155 | 170 |
| RUN 4 | 152 | 266 | 240 | 257 | 158 | 205 | 171 | 250 | 155 | 261 |
| RUN 5 | 152 | 188 | 240 | 259 | 158 | 214 | 171 | 242 | 155 | 222 |

DOMAIN MAXIMA - CT

| RUN | 0716 | | 0721 | | 0722 | | 0806 | | 0808 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | OBS | PRED | OBS | PRED | OBS | PRED | OBS | PRED | OBS | PRED |
| BASE | 291 | 240 | 303 | 202 | 240 | 181 | 249 | 253 | 246 | 243 |
| RUN 1 | 291 | 153 | 303 | 148 | 240 | 152 | 249 | 151 | 246 | 143 |
| RUN 2 | 291 | 189 | 303 | 167 | 240 | 163 | 249 | 180 | 246 | 171 |
| RUN 3 | 291 | 209 | 303 | 166 | 240 | 164 | 249 | 192 | 246 | 205 |
| RUN 4 | 291 | 238 | 303 | 227 | 240 | 223 | 249 | 249 | 246 | 288 |
| RUN 5 | 291 | 225 | 303 | 233 | 240 | 229 | 249 | 243 | 246 | 260 |

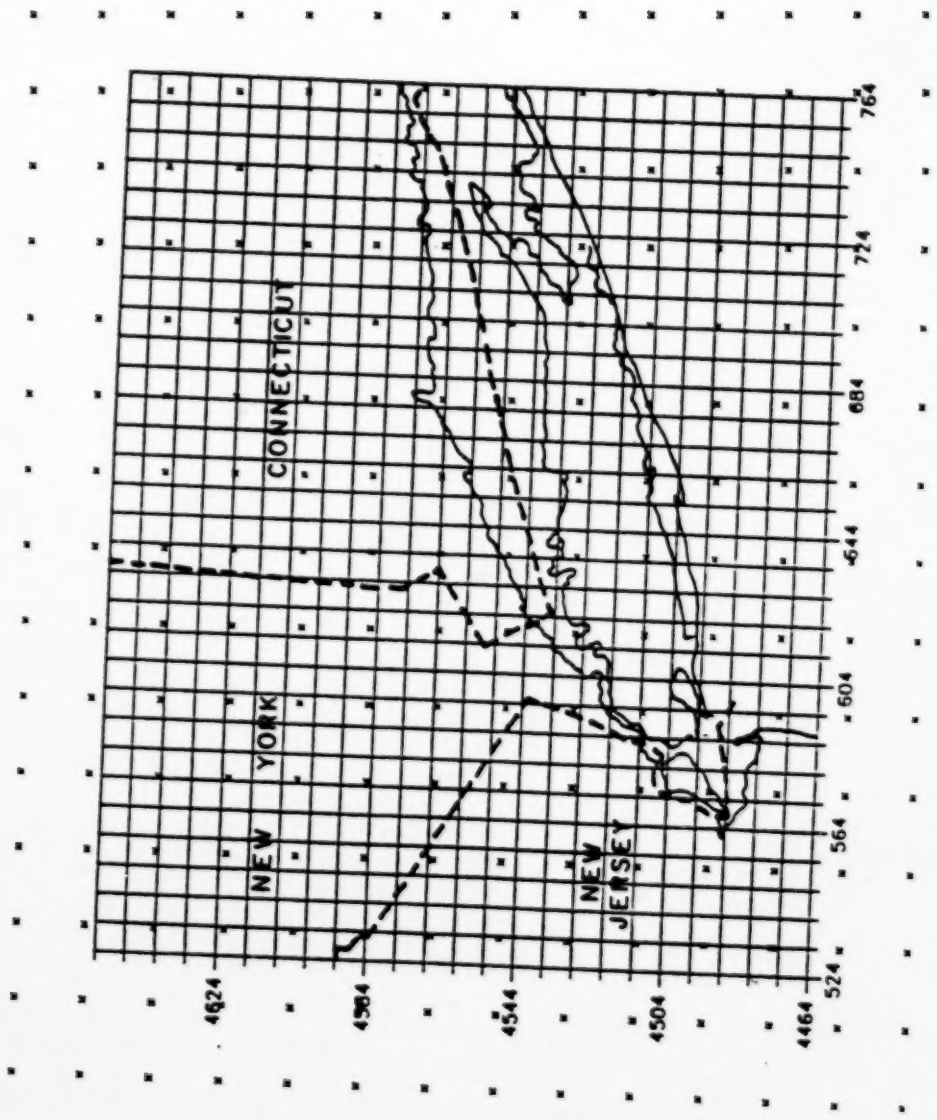
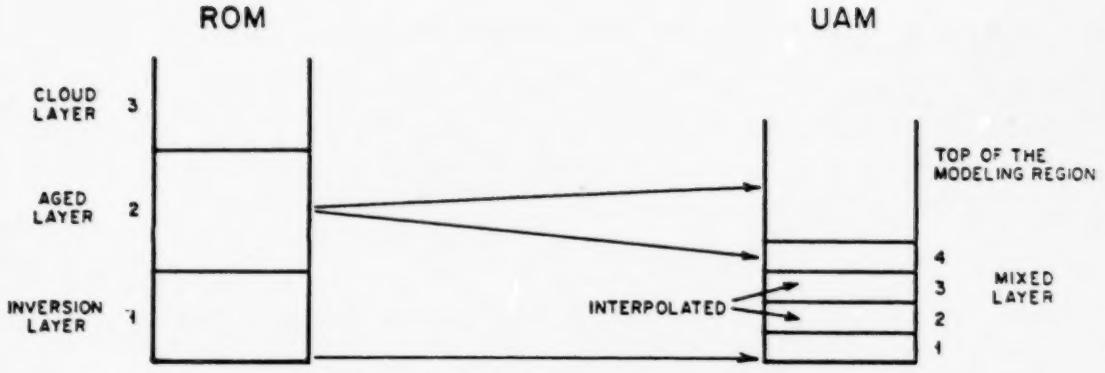
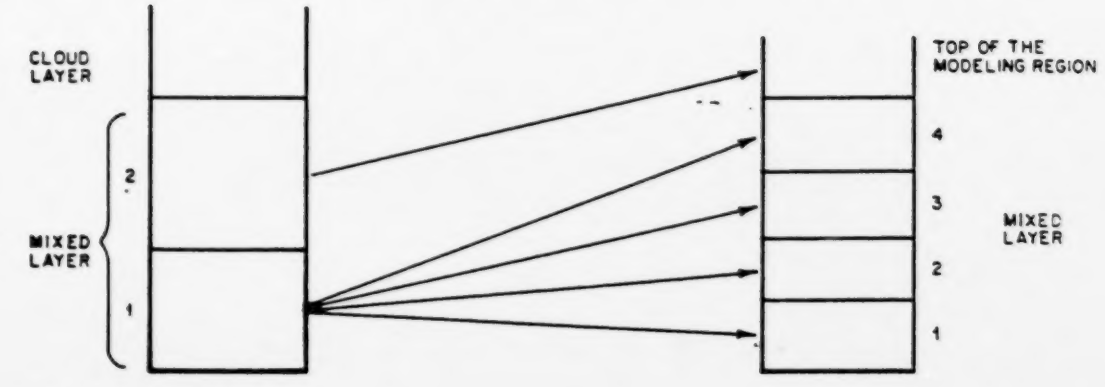



Figure 1 The ROM grid locations (crosses) superimposed over the OMNYMAP grid.




BEFORE INVERSION BREAK-UP (BEFORE 1000 HRS)




AFTER INVERSION BREAK-UP (AFTER 1000 HRS)

**Figure 2** Scheme for the transfer of pollutant concentrations from ROM layers to UAM levels.

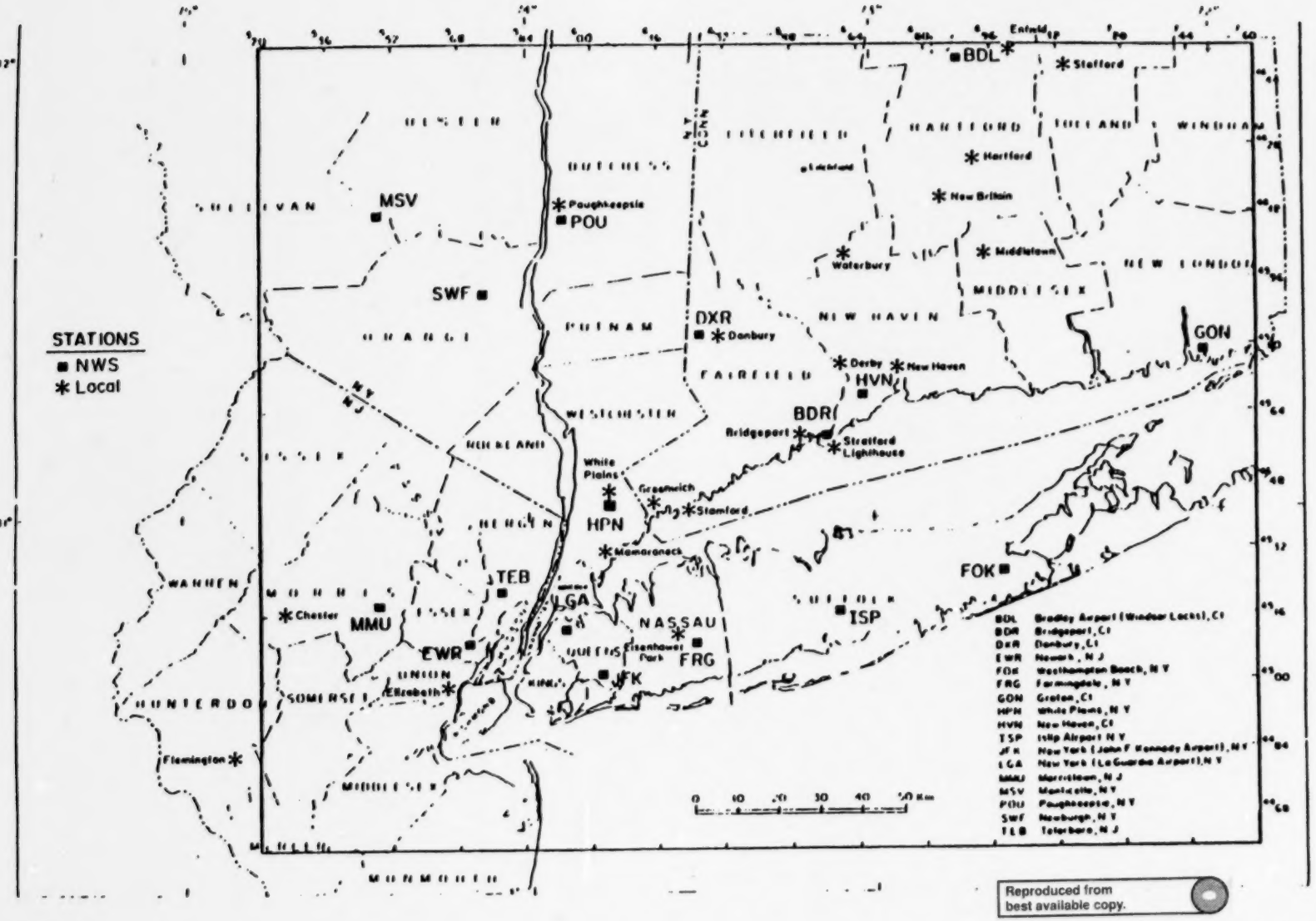



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**Figure 3** NWS and State operated meteorological stations over the UAM modeling domain.

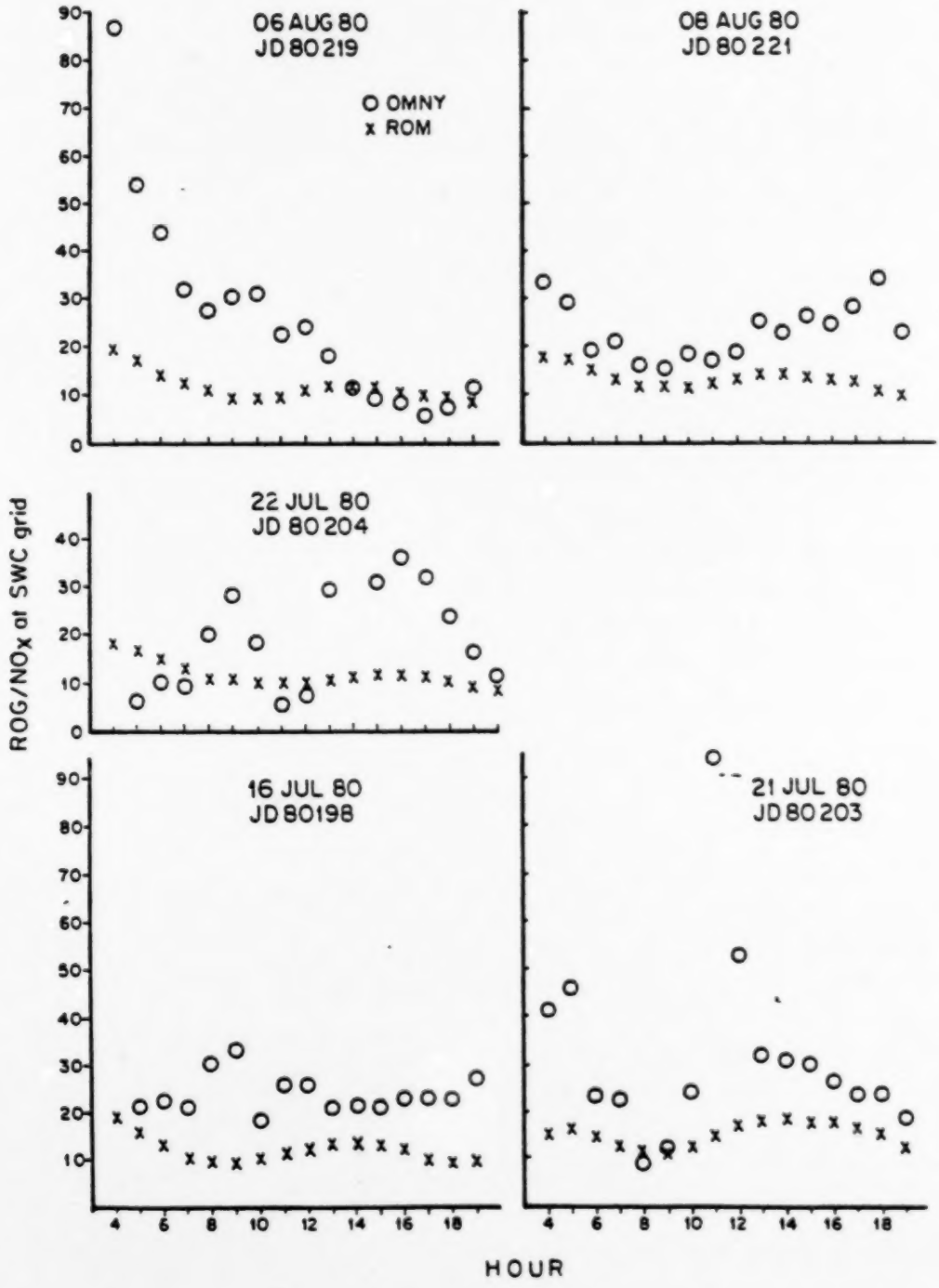



**Figure 4** Diurnal distribution of ROG/$NO_x$ at the South West Corner grid cell of the OMNYMAP domain for the 5 days of UAM simulation.

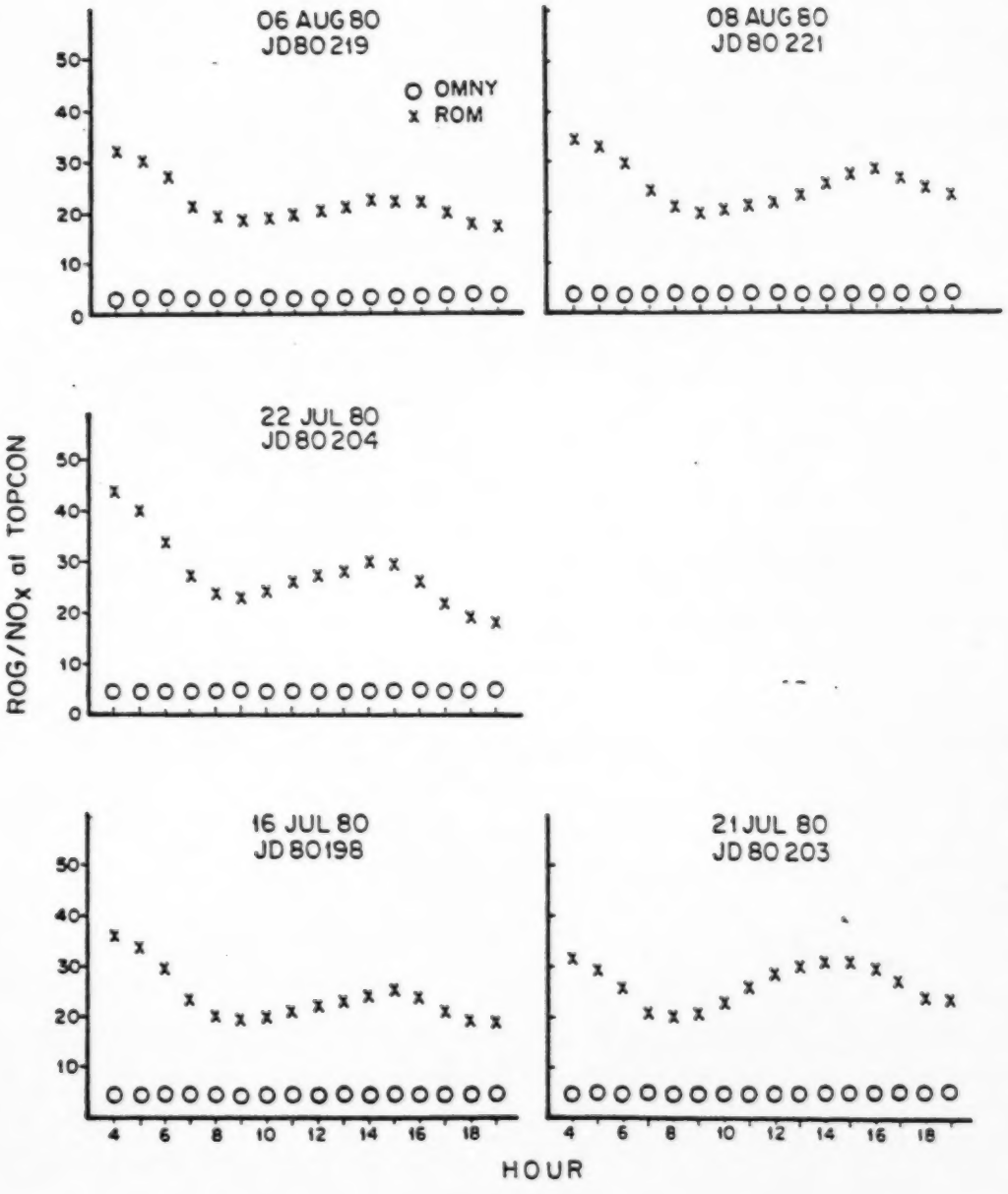
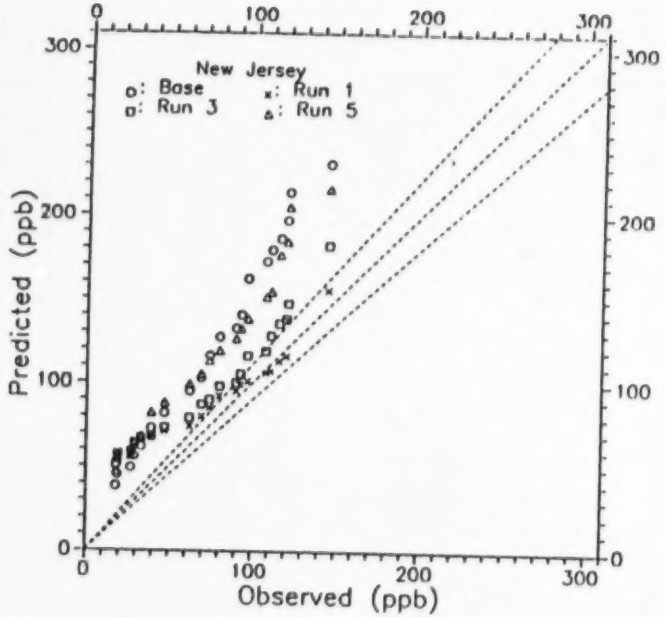
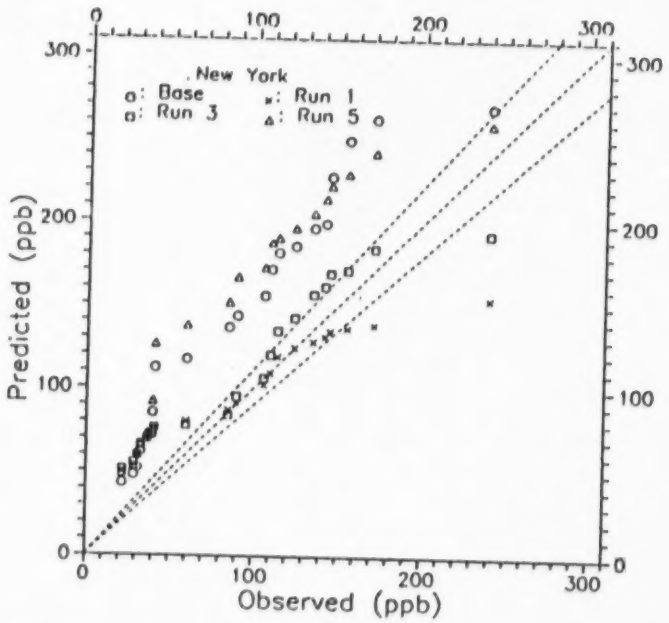



**Figure 5** Diurnal distribution of $ROG/NO_x$ at the top of the modeling region for the 5 days of UAM simulation.



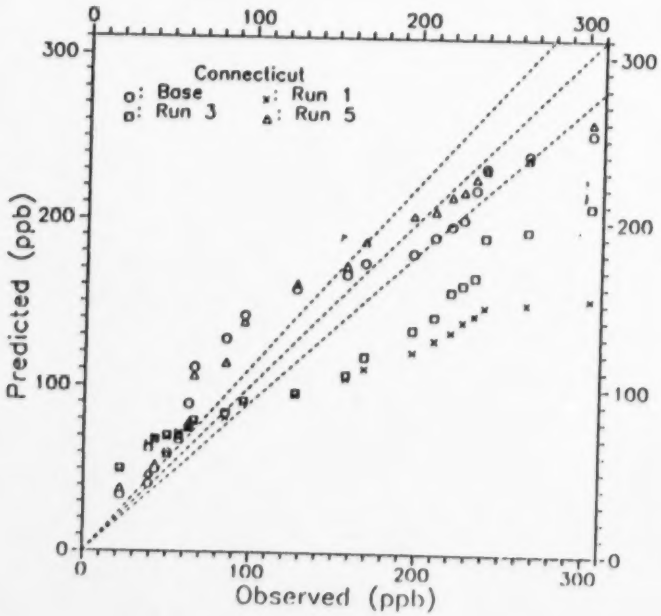




**Figure 6** Cumulative frequency distribution of hourly maximum ozone concentrations measured over the monitoring network and those predicted over the domain at 5th to the 100th percentile, and the ±10% bounds about the one-to-one line for the three geo-political regions.



09-47M.7

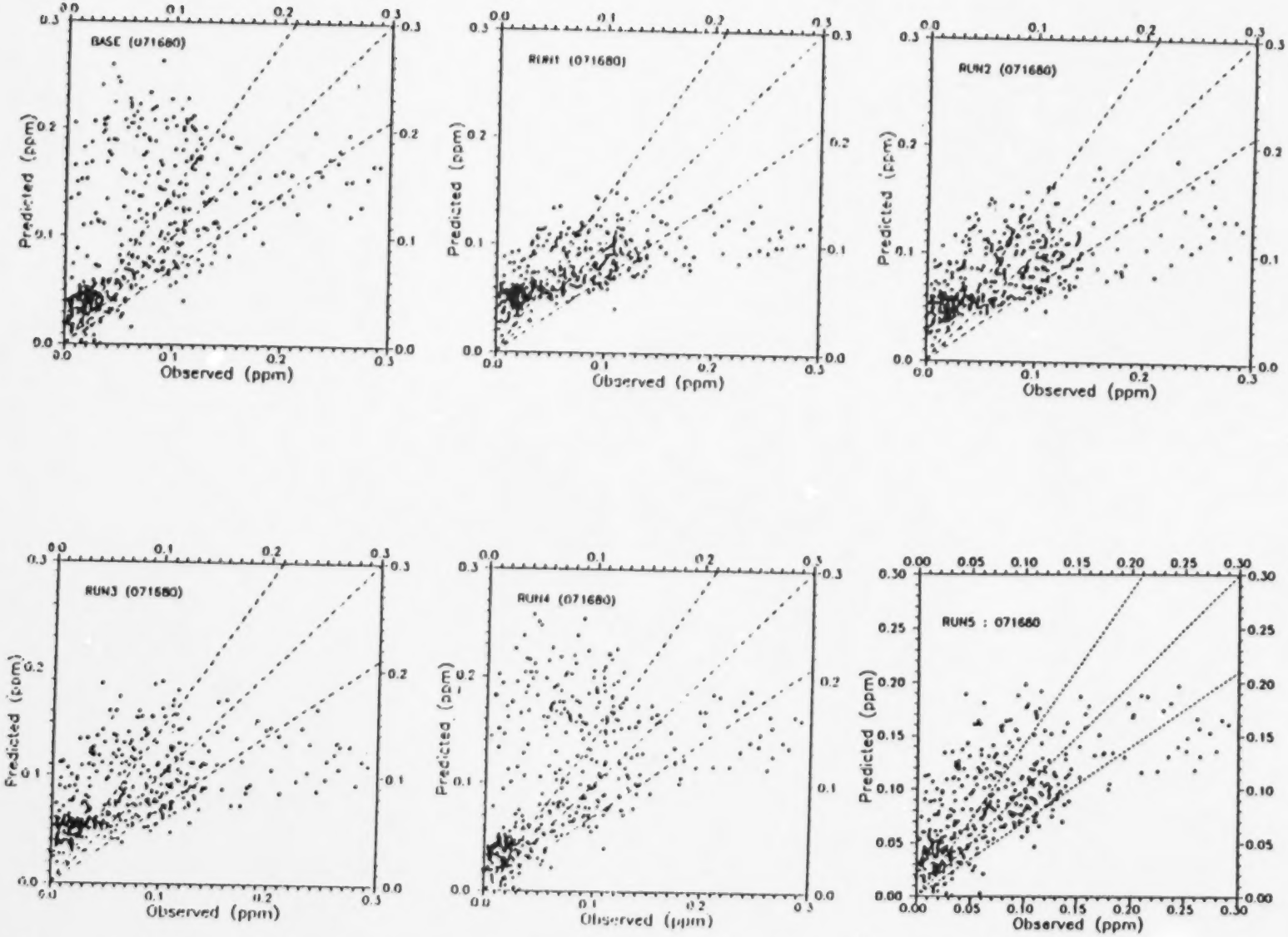



**Figure 7** Plot of observed versus corresponding predicted concentrations over the New York metropolitan area for each of the modeling scenarios for July 16, 1980.

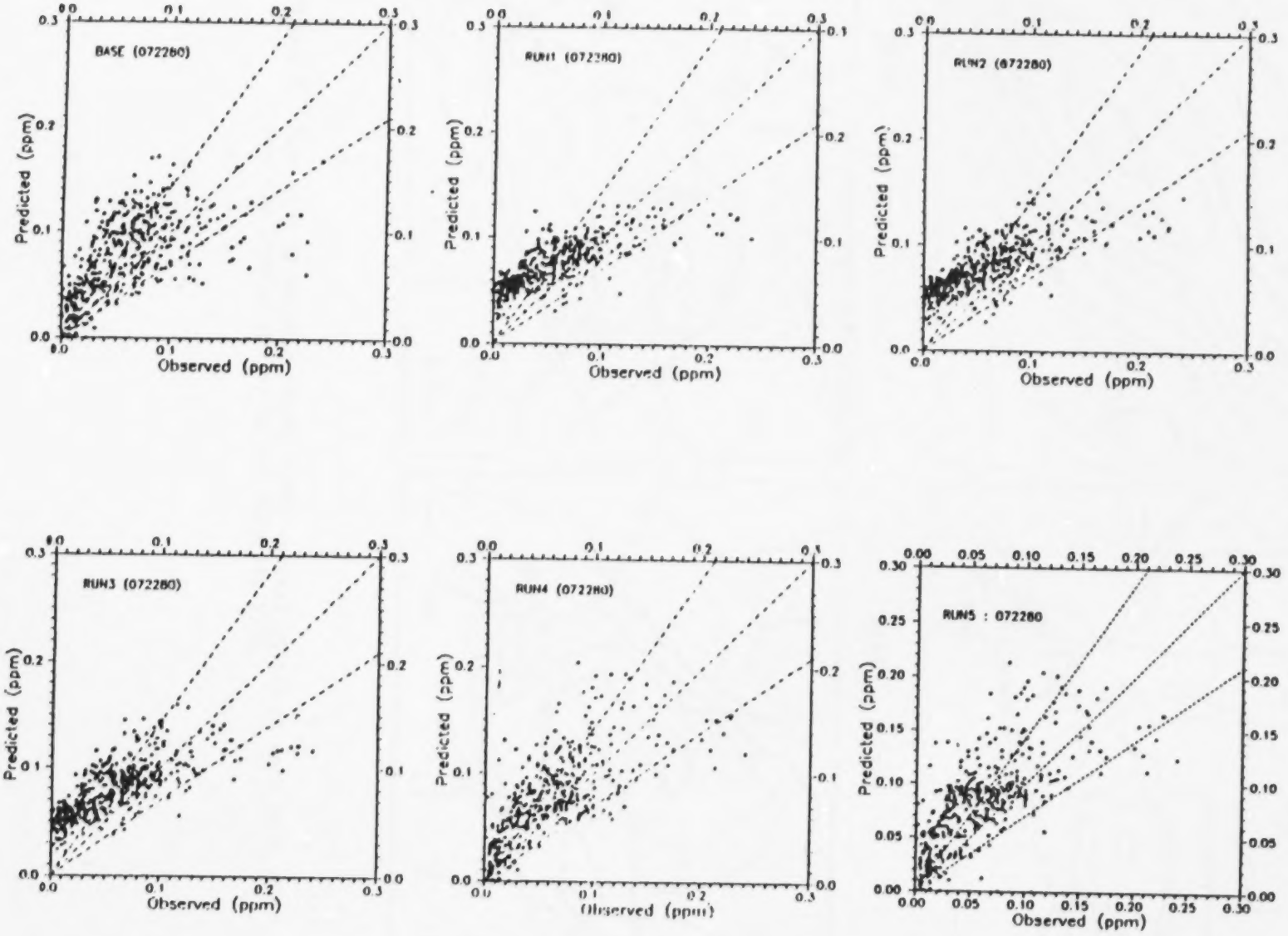



**Figure 8** Plot of observed versus corresponding predicted concentrations over the New York Metropolitan area for each of the modeling scenarios for July 22, 1980.

89-42A.2

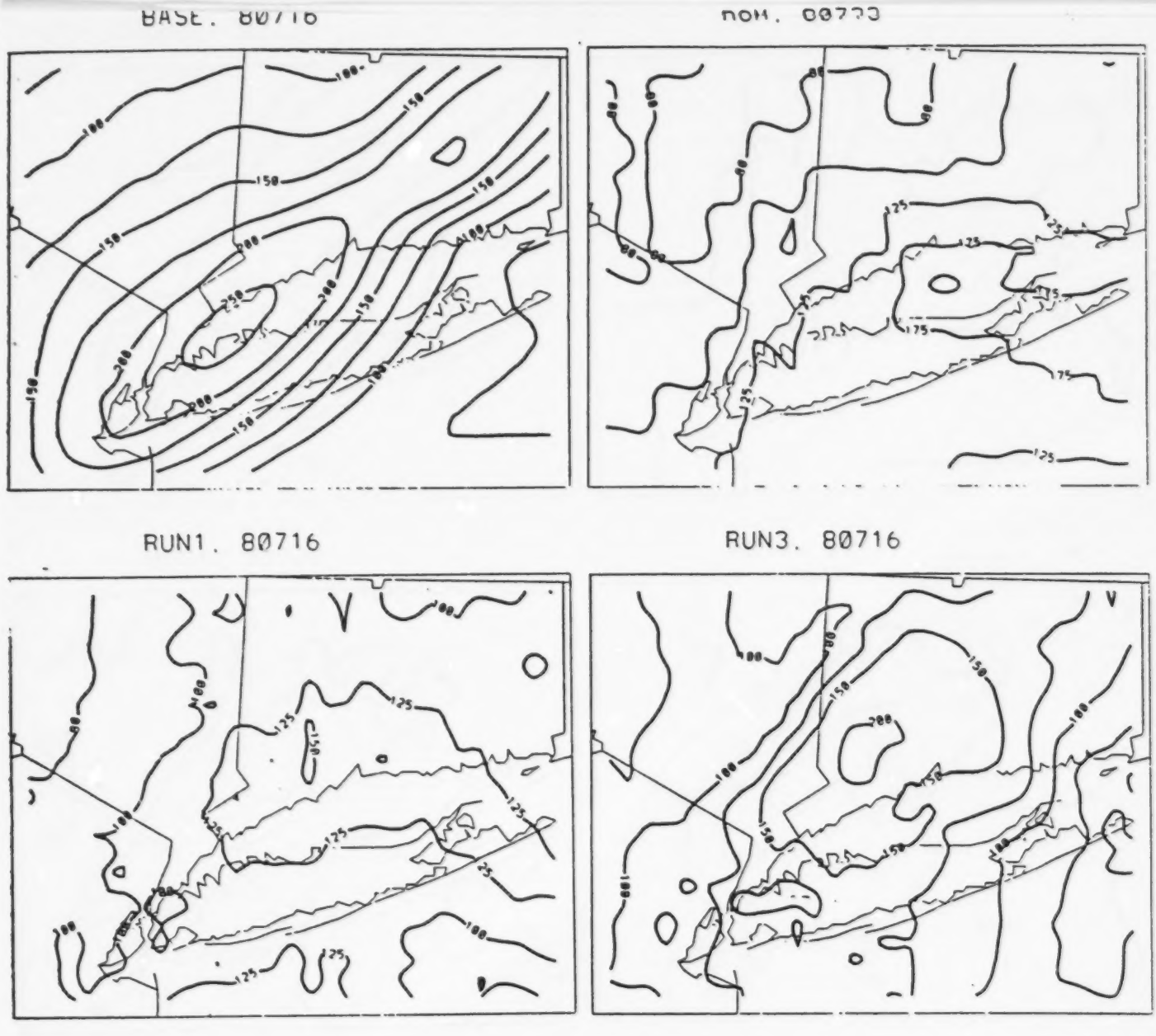



**Figure 9** Isopleths of maximum hourly ozone concentrations at each grid cell over the simulation period for July 16, 1980.

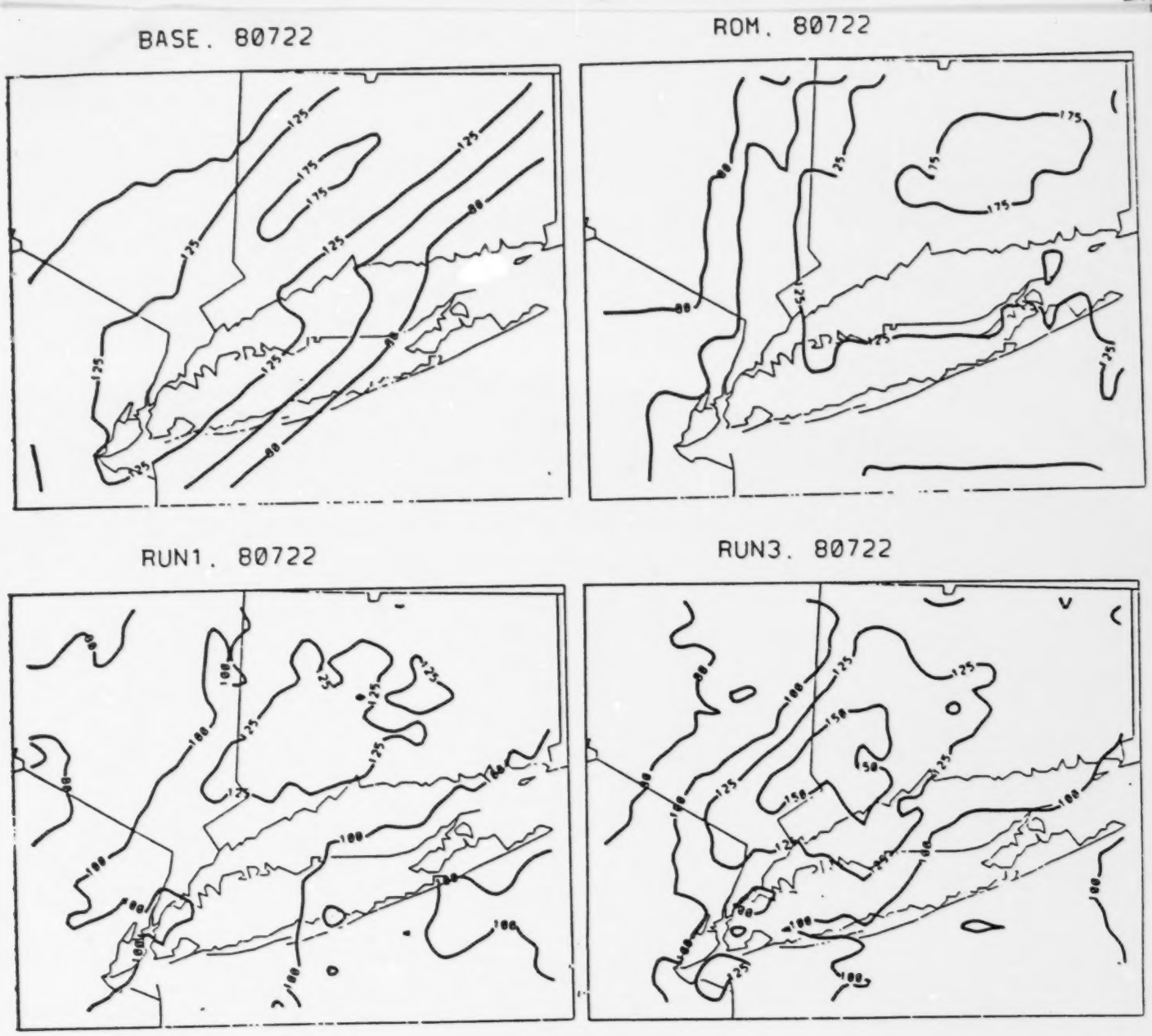



**Figure 10** Isopleths of maximum hourly ozone concentrations at each grid cell over the simulation period for July 22, 1980.